CONNECTING CITIES: ACHIEVING SUSTAINABILITY THROUGH INNOVATION

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Summary:
The internet is making cities more essential than ever through a networked urban infrastructure. Today's cities continue to increase people's access to information and communication. They are connected by a global information and communications infrastructure that facilitates human interaction and mobility. As the new channels for collaboration between people and the design and management of cities, the Internet is leading to dramatic transformations in urban life. The Connected Urban Development program seeks to find visionary and practical approaches regarding technology innovation, and what an urban services platform means for the build-out of sustainable urban infrastructures? In particular, the profound re-focusing of urban networks and services presents opportunities and challenges as communities come to grips with the potential for a networked urban infrastructure.

Key Words:

Connected, Networks, Sustainability, Cities, Smart Grid, Mobility, Work, Energy, Buildings, ICT

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I. INTRODUCTION

In the 21st century, *sustainable development*—the "interdependent and mutually reinforcing pillars of economic development, social development, and environmental protection" (United Nations, 2005)—has emerged as a major strategy and policy priority among government and enterprise organizations globally. To ensure sustainable development, the world faces a number of prominent challenges. Pre-eminent among these are energy use and climate change—and the associated risks of massive environmental degradation that would heavily impact people around the globe.

Today's cities are linked by a global information and communications infrastructure that facilitates communications, human interaction, collaboration, and mobility. As a result, cities are evolving into places where overlapping networks of companies, institutions, civil societies, and citizens are supported by Information Communications Technology (ICT)-enabled flows of people, materials, information, capital, services, and media. What is the impact of urban ICT and broadband connectivity towards carbon-reduction targets, and of innovative urban ICT policy for energy efficiency? This paper presents the hypothesis that the transformational influences of 21st century ICT networks, and the resulting knowledge-based economy, are as significant as the two major waves of "network" innovation that characterized 20th century urban development.

Connected Urban Development (CUD) was born from Cisco's commitment to the Clinton Global Initiative. The CUD program is a partnership with seven cities to promote innovative practices using ICT to reduce CO2 emissions. The CUD partners believe that today's flow of people, goods, energy, information, media, and services in cities can be as efficient as the traffic of digital packets on the internet.

Urban ICT impacts sustainable development of cities in three ways: directly, indirectly, and systemically. The program demonstrates how to reduce carbon emissions by introducing fundamental improvements in the efficiency of urban infrastructure through ICT. The scope of the program transcends the environmental dimension, delivering innovative, sustainable models for urban planning and economic development. The building blocks of the CUD blueprint are connected and sustainable work, mobility, buildings, energy, and socio-economics. This paper introduces some of the best practice initiatives which are aimed as exemplars and catalysts towards a connected and sustainable urban blueprint. The CUD proof of concept projects fit into the wider urban blueprint whereby CUD ultimately envisions a global urban services platform approach for—and among— cities.

II. SUSTAINABLE CITIES

For the first time in human history, the majority of people live in urban areas. With their populations on the rise—60 percent of the world will live in cities by 2030 (UN Habitat, 2008)—cities are experiencing considerable increases in energy consumption. It is expected that by 2010, global electricity use will grow by more than 35 percent—and by more than 75 percent by 2020 (UN IPCC, 2007). Cities are the largest contributor to energy consumption and climate change: cities consume 75 percent of the world's energy and are responsible for 80 percent of greenhouse gas emissions (UN Habitat, 2008).

Cities are centers of innovation, economic growth, social transformation, healthcare, and education—and most are taking a proactive approach to address the urban sustainability challenge. The increasing development of new cities around the globe, however, and the need to renew outdated 20th century infrastructures in mature cities, require the creation of new urban design, metropolitan governance, and infrastructure investment models.

Most attention in sustainable urban development has been directed to three sectors: buildings, energy, and mobility. Today, however, it is becoming evident that a fourth equally important element must be addressed: ICT.

When it comes to urban sustainability, ICT is part of the problem (based on its contribution to overall energy consumption), but an even bigger element of the solution. ICT is a significant contributor to energy efficiency: for every extra kilowatt-hour of electricity demanded by ICT, the U.S. economy increases its overall energy savings by a factor of ten (ACEEE, 2008).

Sustainability and ICT are emerging at the commencement of the 21st century as two sides of the same coin: both are innovations for cities seeking to improve their environmental effectiveness in the context of connected societies, global competitiveness, economic development, climate change, and demographic shifts.

III. THE ROLE OF ICT IN SUSTAINABLE URBAN DEVELOPMENT

Historically, urban development made communications and human interaction easier through concentrated physical development. Before ICT, all communications needed physical movement. Cities developed as spatially fixed places supported by a massive fabric of land parcels, buildings, streets, neighborhoods, and the material transportation and infrastructure networks required to support the physical flow of goods, people, and resources. Sustainable urban development is no further viewed in such narrow terms.

Today’s cities are linked by a global information and communications infrastructure that facilitates communications, human interaction, collaboration, and mobility. As a result, cities are evolving into places where overlapping networks of companies, institutions, civil societies, and citizens are supported by ICT-enabled flows of people, materials, information, capital, services, and media.

We believe that the transformational influences of 21st century ICT networks, and the resulting knowledge-based economy, are as significant as the two major waves of “network” innovation

that characterized 20th century urban development. The first happened at the beginning of the last century, triggered by the age of steel, electricity, and heavy engineering, resulting in electrical networks. The second took place at mid-century, with the automobile and other forms of transportation spurring suburbanization and sprawl through networks of roads, highways, ports, and airports.

Today, worldwide digital communications and the Internet are becoming the fourth utility in cities (in addition to roads, water, and electricity). Similar to the beginning of last century, when newly built electrical networks were the focus, today's citizens, governments, and enterprise organizations are taking advantage of digital services delivered over the internet.

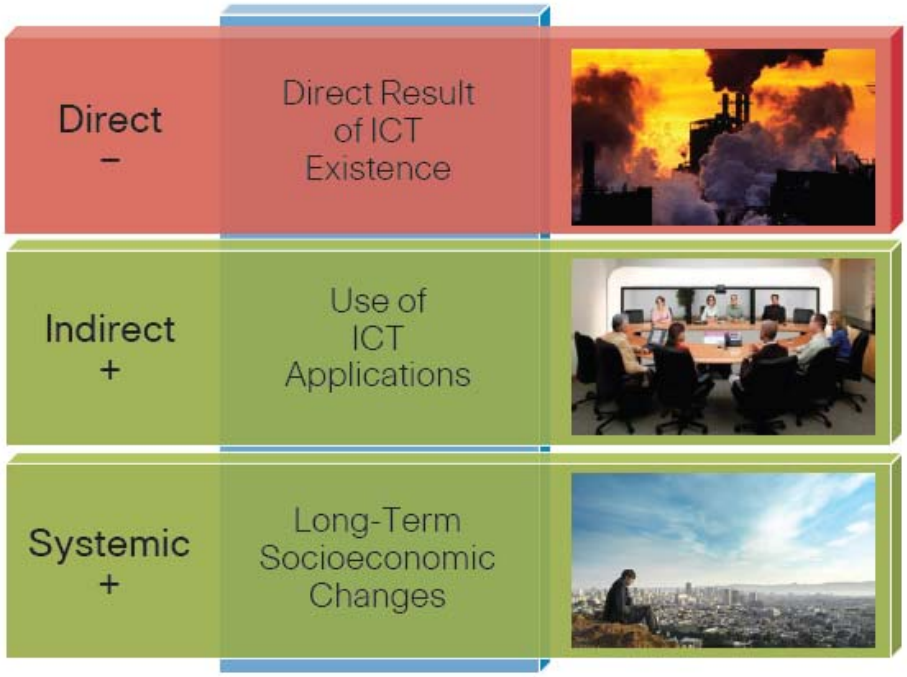
High broadband growth and penetration rates are no longer restricted to developed northern European and northeast Asian countries and cities. Global internet penetration has reached 23.8 percent (Internet World Stats, 2009) while the quality and speed of access have increased dramatically as well.

In the last three years, for example, Paris moved from being a broadband laggard to becoming the most fiber-enabled city in the world, thanks to forward-thinking public policy. Thailand, the Philippines, Indonesia, and Greece have witnessed spectacular growth in national broadband penetration and speed. While Japan's fiber-to-the-home penetration increased to 16 percent (FTTH Council, 2009) of total homes, and the city of Seoul's total internet penetration is approaching 100% (Mok, 2009) of the population, countries such as South Africa and Australia have launched aggressive broadband development programs. Furthermore, Broadband-based internet access is becoming a reality for rural communities in developing countries, such as for the Himalayan villagers of Dharamsala in India, thanks to an initiative by local entrepreneurs called AirJaldi.

IV. THREE EFFECTS OF ICT-ENABLED SUSTAINABLE URBAN DEVELOPMENT

Virtually all proposed solutions to energy consumption and climate change (Stern, 2006) and (IPCC; 2001, 2007), acknowledge the role ICT plays as a key enabler of environmental effectiveness in large metropolitan areas. The Smart2020 report (The Climate Group, 2008) addresses exactly *how* urban ICT and broadband connectivity can help, and what the carbon-reduction impact of innovative urban ICT policy for energy efficiency can be.

Figure no.: 1 Effects of ICT-enabled Sustainable Urban Development



Source: Cisco IBSG, 2008

Any discussion of sustainable urban development must acknowledge that ICT is part of the problem facing cities today, based on its ever-increasing levels of energy consumption. This downside, however, is more than mitigated by ICT's valuable contributions to energy efficiency, its ability to reduce energy demand in other activities (e.g., using tele-working to reduce trips to the office), and the existence of ICT applications that increase the efficiency of energy used in these activities (e.g., car routing that cuts traffic congestion).

We believe that urban ICT impacts sustainable development of cities in three ways: directly, indirectly, and systemically.

• Direct effects are caused by the physical existence of urban ICT infrastructures. They are resource-intensive in manufacturing and distribution, consuming ever-greater amounts of energy and creating escalating volumes of solid and toxic waste. Mature cities already estimate that the direct ICT contribution to their energy consumption ranges between 5 percent and 15 percent (Fraunhofer Institute, 2001; Global Action Plan, 2007; Lawrence Berkeley National Laboratory, 2001; McKinsey, 2007). More energy-efficient ICT solutions and architectures are being rapidly developed at the industry level, where businesses are starting to collaborate on the creation of consortia and initiatives.

• Indirect effects stem from the use of broadband and ICT applications. They are the essential driver for productivity improvements and innovation (for instance, the virtualization of government and business services), as well as for more efficient management, control, and visualization of urban networks (buildings, energy production and use, mobility, water and sewage, open spaces, public health, and safety). For example, one U.S. study (Fuhr and Prosiask, 2007) projects that use of broadband could save 1 billion tons of greenhouse gases over ten

years—representing 11 percent of annual oil imports—through transportation substitution and dematerialization.
• Systemic effects link the network impact of ICT to society and urban planning at large. ICT innovations are catalysts of structural change for personal, work, and community life that will result in the development of more distributed, compact, and mixed-use urban forms. Green real estate development in densely populated locations could have the most significant impact on sustainable urban development, reducing energy consumption from the average suburban U.S. household by 75 percent (Segel, 2007).
– Access to global networks and ICT resources is a requirement for individual and community success in the information age—and for driving the kind of continuous innovation that will be essential to competing successfully in the global economy. With proper focus, planning, and policies, cities can be centers of ICT-enabled innovation for sustainable growth.

Although these three ICT-enabled effects will have the most significant impact on urban sustainability, they are not yet well understood. Our fundamental belief is that today's flow of people, goods, energy, information, media, and services in cities can be as efficient as the traffic of digital packets on the internet.

V. THE CONNECTED URBAN DEVELOPMENT PROGRAM

Attempts to reduce carbon emissions by cutting consumption of greenhouse gas-producing fuels have been largely unsuccessful. Reduction of energy consumption is viewed by many as counterproductive to economic growth, and such measures have been difficult to implement and impossible to enforce. Developing a new way of approaching the problem is critical, given the urgency posed by rapid climate change.

Connected Urban Development (CUD) was born from Cisco's participation in the Clinton Global Initiative—launched by the William J. Clinton Foundation in 2005 to solve global problems that affect the quality of human life—to help reduce carbon emissions and improve energy efficiency.

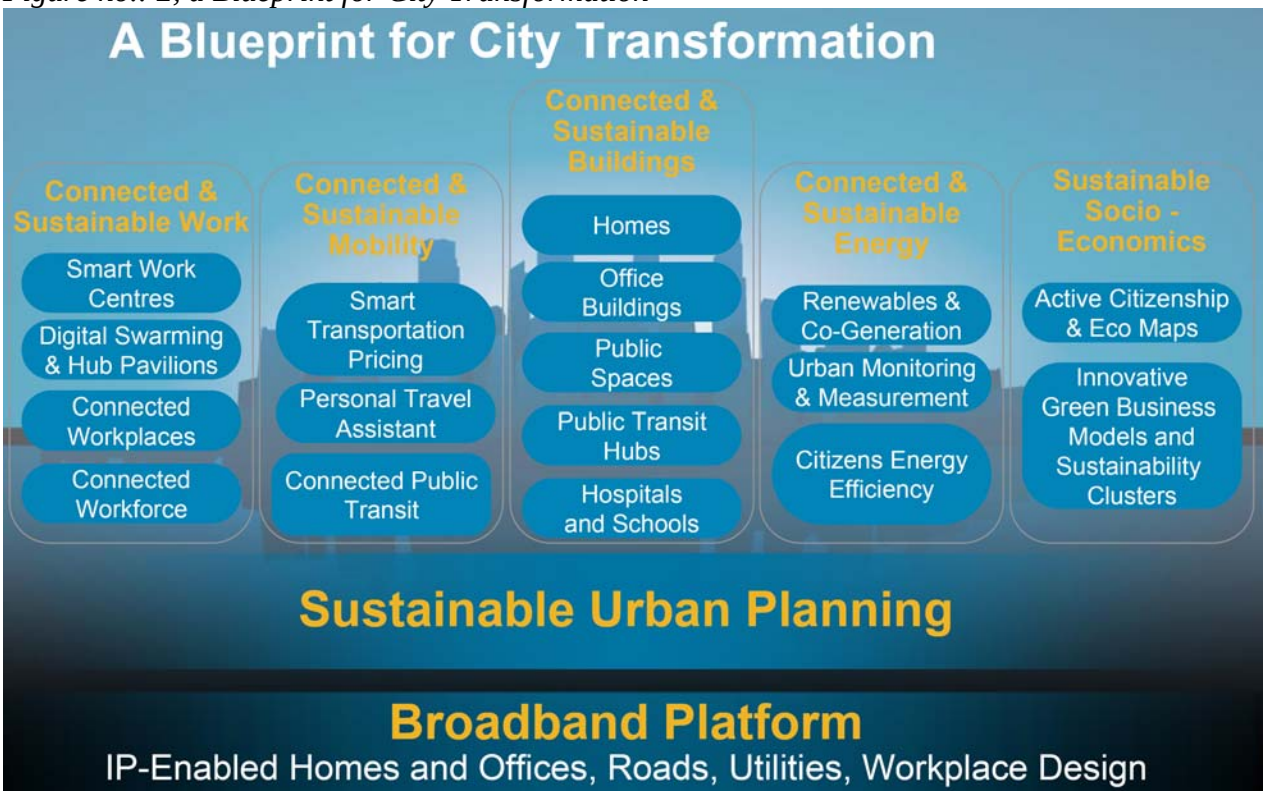
The CUD program initially involved three pilot cities: San Francisco, Amsterdam, and Seoul. These cities were selected because each had implemented or planned to execute a next-generation broadband (fiber and/or wireless) infrastructure; each suffers from significant traffic congestion issues; and each is led by a visionary mayor already involved in green initiatives. In 2008, four further cities joined the program: Birmingham, Hamburg, Lisbon, and Madrid. CUD relies heavily on the leadership of city mayors—and their commitment to ICT-enabled sustainability.

The CUD team is building partnerships with these cities to promote innovative practices using ICT to reduce CO2. Each of these cities is focused on excelling in one or two key areas. The result will be a blueprint of best practices and methodologies that other cities can reference in the second phase of the program, which will focus on scaling CUD's benefits to other cities around the globe. The building blocks of the CUD blueprint are work, mobility, buildings, energy, and sustainable socio-economics.

The solutions currently in progress target the following areas:

- Increase in efficiency of traffic flows
- Increasing efficiency, service offerings and manageability of public transportation
- Creating sustainable real estate models which incorporate energy efficiency and new work environment models (remote worker, collaboration, shared space, etc.)
- Establishing new distributed delivery models for city services to its residents
- Enabling new resident services to self-manage carbon footprint

Figure no.: 2, a Blueprint for City Transformation



Source: Cisco IBSG, 2009

VI. THE FOUR PRINCIPLES OF CUD

CUD is based on four principles:

1. ICT directly contributes both to energy usage and CO2 reduction. Industry efforts aimed at developing energy-efficient technology solutions can contribute to a sensible reduction of the environmental footprint in cities. But collaboration between government and industry, along with development of effective policy, are essential to a successful greening of ICT.
2. Deploying broadband-based applications and services improves energy efficiencies. These can be clustered in four major areas: Connected and Sustainable Built Environment, Connected and Sustainable Mobility, Connected and Sustainable Work, and Connected and Sustainable Energy.
3. Urban pervasive broadband infrastructure and continuous development of application and services clusters can enable radically innovative practices in the areas of urban form and planning, energy policy, new working practices, and new lifestyles. ICT pervasiveness and the

emergence of Web 2.0 are having dramatic implications on the socioeconomic tissue of a city, as well as on its energy-efficiency policy.
4. ICT and broadband connectivity have become enablers of combined, citywide urban policy, and of previously disconnected operational programs. Integration of data and processes across siloed government initiatives is becoming a reality. Mobility, Built Environment, and Energy-related efficiency initiatives can now be successfully combined into integrated urban development programs.

The program demonstrates how to reduce carbon emissions by introducing fundamental improvements in the efficiency of urban infrastructure through ICT. The CUD approach is different because it changes the way cities work and how they utilize resources. The scope of the program transcends the environmental dimension, delivering innovative, sustainable models for urban planning and economic development. Cisco's Corporate Development organization is investing US$15 million in the program over five years, including people, research, and equipment. Cisco Internet Business Solutions Group (IBSG) manages the project and supports each city's strategic planning process by creating or acquiring research and providing analysis.

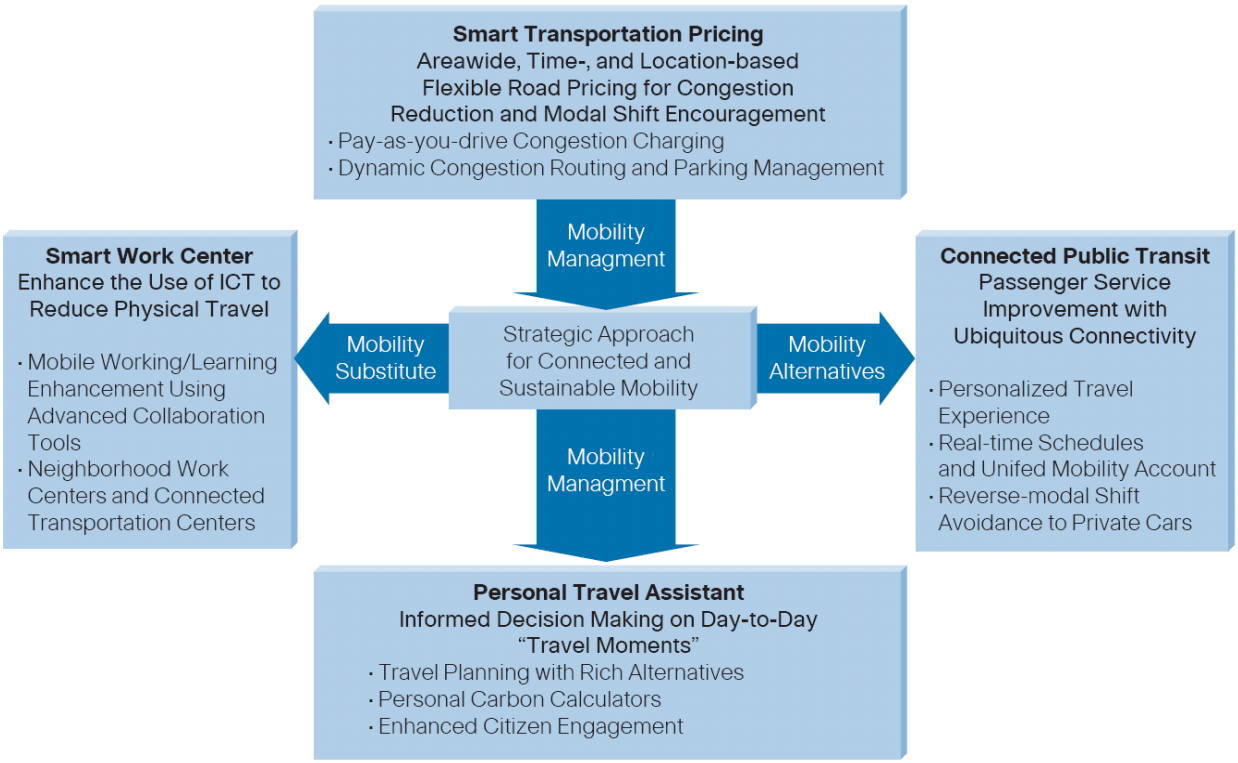
This paper introduces some of the best practice initiatives which are providing proof of concept exemplars for the connected and sustainable urban blueprint.

VII. CONNECTED AND SUSTAINABLE MOBILITY SOLUTIONS

Strategic Approach
There are good examples of partial solutions that address specific local or modal issues. A strategic set of solutions takes into account all economic, social, and environmental impacts, including those that are indirect, not marketable, or long-term.

Integrated Solutions Approach
Although individual solutions may appear to impact urban mobility modestly, their combined benefits can be substantial. Therefore, an integrated approach is required to support a combination of mobility solutions systematically and make use of the dramatic changes that have occurred in the proliferation of ubiquitous connectivity. An example of this could be a particular program that includes improving public transit services and establishing pricing schemes for road use and parking fees, providing users more travel options and incentives. A strategic approach to a successful urban transportation system is shown in Figure 3.

Figure no.: 3 Integrated Approach for Connected and Sustainable Mobility



Source: Cisco IBSG, 2008

Integrating a comprehensive solutions portfolio around options, incentives, encouragement, enforcement, and compliance enables a city to put more power of choice into citizens' hands, as well as improve municipal human and asset capital management.

Smart Transportation Pricing

Smart transportation pricing provides cities with intelligence and flexible tools to manage transportation demand in urban areas. It enables cities to charge intelligent fees for road use and communicate transportation-related information in real time, taking advantage of Global Positioning Systems (GPS) and wireless communications technology.

Smart transportation pricing requires several key capabilities to be successful:

• Effective mobile communications infrastructure to exchange data in real time.

• GPS to locate commercial vehicles for obtaining accurate data about time, itinerary, and distance. City government can use the data to design or revise road-use pricing schemes.

• Wireless communications technology to enable commercial vehicles to exchange critical information associated with smart transportation with city operations centers in real time.

• Flexible road-use pricing schemes that combine a pricing tool with a standard electronic city map.

• Integrated transportation services payment systems for drivers. Knowing the total cost of transportation, including road tolls and parking, is important for drivers to make the right decision about their travel methods. Also, users can conveniently pay for transportation services through a universal mobility account, which is an integrated payment system.

Personal Travel Assistant

Personal Travel Assistant (PTA), a service developed by Cisco with input from the Massachusetts Institute of Technology (MIT), improves the transit experience within urban environments. PTA enables cities to provide users with travel information in a convenient format through various service channels, including transit stations and vehicles, websites, and mobile devices such as Personal Digital Assistant's (PDA). It can incorporate various smart travel assistant features that provide intelligent and dynamic guidance based on user profile and context (conditions of a particular travel corridor at a particular time) using real-time information. The proof of concept for this approach is currently taking place in 2008/09 in Amsterdam and Seoul (Connected Urban Development, 2009).

Connected Public Transit

Connected Public Transit (CPT) is a set of information services that improves passengers' experience through ubiquitous connectivity. CPT is intended to make public transit convenient, comfortable, efficient, affordable, and reliable. It can incorporate various "smart traveler" features that provide dynamic (changeable) guidance based on user profiles and context using real-time information. Some CPT features will integrate with PTA services that use handheld devices and public monitors located at transit stops and on transit vehicles to provide information to users. The proof of concept for this approach took place in 2008/09 in San Francisco (Connected Urban Development, 2009).

Urban Mobility Business and IT Architecture

Connected urban infrastructure presents cities with an opportunity to develop platforms for provisioning services to citizens, transportation agencies, and private-sector stakeholders. As cities expand and change quickly, requirements for efficient traffic flows and information services change just as rapidly. Sustainable transportation systems must be capable of being reused and adapted for different requirements.

Connected and Sustainable Mobility uses a general-purpose, urban-wide platform based on a standard architecture and open interface to improve reusability of its components. This standard architecture will allow cities to manage the platform as it evolves and adapt to rapidly changing demands and technology opportunities.

VIII. CONNECTED AND SUSTAINABLE WORK

Connected Urban Development's approach is based on understanding the opportunities technology offers for enabling sustainable patterns and blueprints for human exchange and enterprise. Because of the impact of work on adoption of these patterns and, ultimately, on development of a model for a sustainable and livable city, CUD believes the opportunity to introduce innovation in work enablement using ICT is equally important to delivering solutions to problems for energy, transportation, housing, buildings, and society at large.

Traditional models of knowledge work included elements such as office space, co-location of teams, and time-based employee performance metrics. Today, these models fail to fully realize technology's potential for increasing productivity, minimizing the impact of travel on the environment, and reducing inefficient use of space and energy in offices, as well as for addressing the long-term impact of stress on workers' health and productivity.

Now, more than ever before, knowledge workers are opting for more collaborative and flexible forms of work that allow them to contribute when they want, from virtually anywhere, and with almost anyone. At the same time, the speed demands and complexity of knowledge work have increased significantly, driving the need to collaborate and engage a broader workgroup to obtain needed results. The convergence of these factors is spawning new paradigms for how work gets done, along with great opportunities to innovate.

The CUD vision of Connected and Sustainable Work aims to influence the evolution of knowledge work, the principles of sustainable work, and solutions that incorporate these principles. The main objective is to provide cities, employers, and citizens with a new framework for fostering economic growth, increasing the quality of life in cities, and addressing the challenges of climate change.

Smart Work Centers—Bringing Work Closer to the Worker
A Smart Work Center (SWC) is an office center in close proximity to a residential community, providing space to workers in individual or group settings. Through the use of ICT, all work processes are fully supported and enhanced. Employers can take advantage of this collective setting to provide workers with flexible and scalable workspace options. The use of SWCs benefits workers by providing a physical workspace close to their residences, resulting in reduced transportation demands and increased productivity.

Hub Culture Pavilions—Using the Physical and Virtual Workspace
The Hub Culture Pavilion concept consists of a global network of urban physical spaces, or "Pavilions," that deliver a real-world communication platform linking points of interest between local and remote locations. Each pavilion venue acts as a unique node within the global Hub Pavilion network while interacting with other venues.

Benefits to the Urban Environment
The implementation of Smart Work Centers by Amsterdam and the deployment of Hub Culture Pavilions in cities around the world demonstrate that there is interest in innovation around work by cities, workers, and employers. As (Florida, 2002) states, "Access to talented and creative people is to modern business what access to coal and iron ore was to steelmaking. It determines where companies will choose to locate and grow, and this in turn changes the ways cities must compete."

IX. CONNECTED AND SUSTAINABLE BUILDINGS AND ENERGY

Cities around the world are realizing that energy consumed by buildings and homes is the leading cause of global-warming emissions. This includes electricity and fossil fuel used to light, heat, and power our homes, apartments, office buildings, and factories. In fact, New York City estimates that energy usage causes roughly 80 percent of its global-warming emissions and more than 40 percent of locally generated air pollution. By 2015, New York City estimates (Mayor Bloomberg, 2007) it will be pumping an additional 4.6 million tons of CO2 into the atmosphere each year. The cause is a growing demand for energy, combined with aging electricity infrastructure. New York City's electricity demand is forecast to grow 44 percent by 2030. Many plants that generate electric power are more than 30 years old (with outdated technologies), use

30 to 60 percent more fuel, and produce several times the air pollution of newer plants to generate the same amount of electricity.

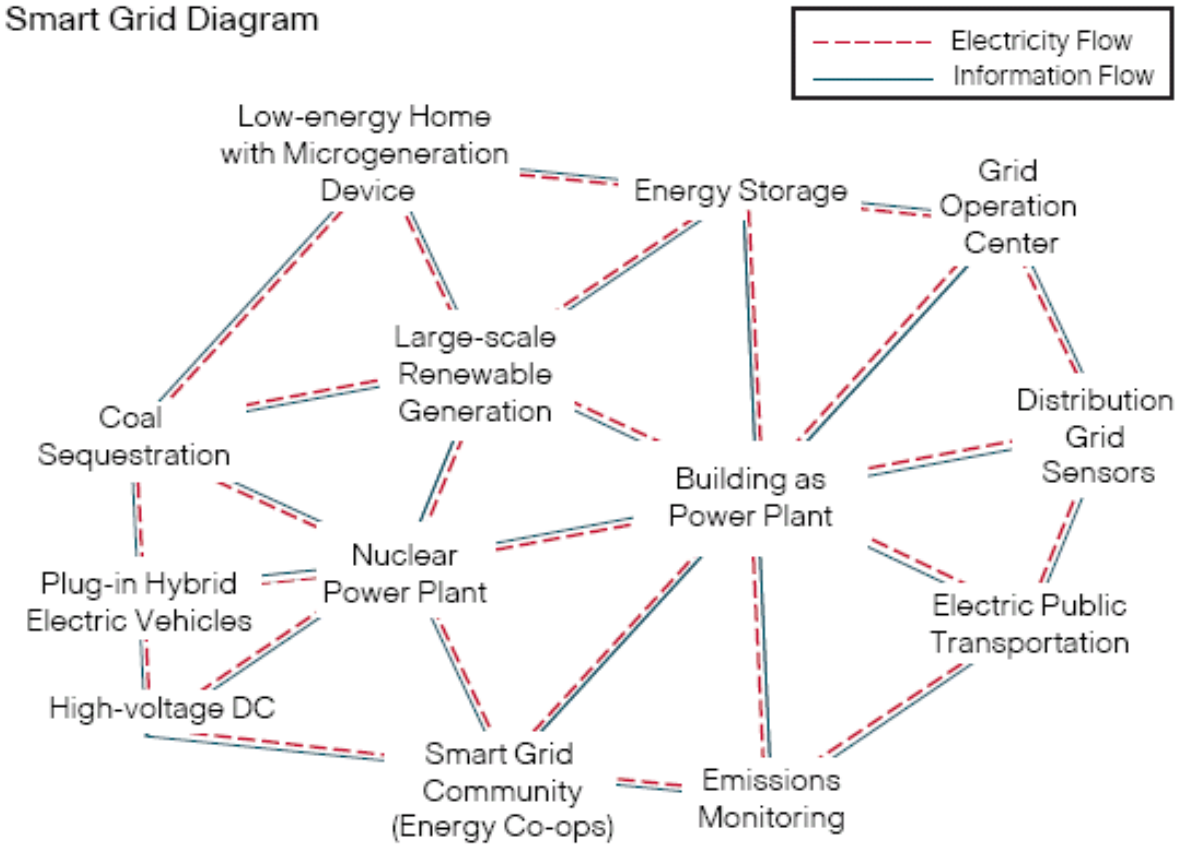
But energy poses additional challenges for city leaders. Our demand for electricity continues to grow, increasing consumer costs. New York City estimates that by 2015, the city's annual electricity and heating bill will grow by $3 billion—translating into annual energy bills that are $300 to $400 higher per household. By 2030, New York City forecasts electricity costs will rise 60 percent above today's.

Clearly, city leaders working to reduce their impact on climate change need to focus carefully on how energy is generated, distributed, and consumed throughout their city. What can be done? Leading cities are creating dedicated ministries and departments to develop integrated strategies to meet our growing demand for energy while mitigating its impact on climate change. There is no easy solution, and cities must focus both on reducing energy consumption of residents and industry while accelerating greener energy-generation plants.

The emerging solutions for city leaders to reduce electricity consumption, produce greener energy with lower carbon emissions, and improve the reliability of the electric grid. A new, more intelligent electric system or "Smart Grid" is required that combines information technology (IT) with renewable energy to significantly improve how electricity is generated, delivered, and consumed (see Figure 4). A Smart Grid provides utility companies with near-real-time information to manage the entire electrical grid as an integrated system—actively sensing and responding to changes in power demand, supply, costs, and emissions—from rooftop solar panels on homes, to remote, unmanned wind farms, to energy-intensive factories.

A Smart Grid is a major advance from today, where utility companies have only basic information about how the grid is operating, with much of that information arriving too late to prevent a major power failure or blackout.

Figure no.: 4 Traditional Roles Are Reversed with a Smart Grid—Consumers Become Producers, and Information and Electricity Flow in Both Directions



Source: Cisco IBSG, 2008

Components of a Smart Grid

A Smart Grid comprises three major components: 1) demand management, 2) distributed energy generation, and 3) transmission and distribution grid management.

• Demand Management: Reducing electricity consumption in homes, offices, and factories. Demand Management includes:

– *Demand Response:* During emergency periods of peak energy usage, utility companies send electronic messages to alert consumers about reducing their energy consumption by turning off (or turning down) unessential appliances.

– *Smart Meters and Variable Pricing:* In many areas, electricity prices rise and fall based on demand at that moment. "Smart meters" let consumers shift energy consumption from high-priced periods to low-priced periods (load shifting and shedding).

– *Smart Buildings with Smart Appliances:* Traditional, stand-alone building control systems are now converging onto a common ICT infrastructure that allows appliances (heating, ventilation, air conditioning, lighting, and so forth) to "talk" to each other, coordinating their actions and reducing waste.

– *Energy Dashboards:* Online energy dashboards provide real-time visibility into energy usage while suggesting ways to reduce consumption.

• Distributed Energy Generation: Encouraging homes and businesses to install their own renewable energy sources. Distributed Energy Generation includes:
– *"Microgeneration":* Some homes and offices generate their own electricity locally using small equipment (wind generators, photovoltaics, fossil-fuel generators with heat reclamation). Many of these devices are now as affordable as energy from utilities, and produce 50 percent less greenhouse gases.
– *Storage and Hybrid Electric Vehicles:* Owners of plug-in hybrid electric vehicles (PHEVs) can buy energy when it is inexpensive, store it in batteries, and sell it back to the grid when the price goes up. PHEV drivers hope to arbitrage the cost of power, while utilities see fleets of PHEVs supplying power to reduce peaks in demand.

• Transmission and Distribution Grid Management: Using IT to improve control of the electric distribution grid. Supply-side efficiency in the transmission and distribution grid includes:
– *Grid Monitoring and Control:* Utilities are installing sensors to monitor and control the grid in near real time to detect faults earlier and provide time to prevent blackouts.
– *Grid Security and Surveillance:* Utilities are installing surveillance sensors to monitor and secure unmanned, remote equipment that is vulnerable to terrorism.

A number of Connected and Sustainable Buildings and Energy proof of concept pilots (Connected Urban Development, 2009) are currently in development in the CUD cities. Pilots include *"UrbanEnergy Management"*, a community and home-focused energy controller in Madrid; and *"Smart UrbanEnergy for Schools"*, a smart buildings and energy control application in Lisbon. In Birmingham, an *"EnergyWise*" pilot for the city's ICT infrastructure is currently in beta testing.

X. CONNECTED AND SUSTAINABLE ICT INFRASTRUCTURE

In the policies and plans for sustainability and eco-responsibility in cities, much attention has been directed to three sectors: the built environment, energy, and mobility. At the beginning of the 21st century, it became obvious that a fourth equally important element must be addressed: ICT. When it comes to city sustainability, ICT is part of the problem (based on its contribution to the overall eco-footprint), but more important, ICT is an even bigger element of the solution. A recent study found that ICT is a significant contributor to energy efficiency: for every extra kilowatt-hour of electricity demanded by ICT, the U.S. economy increases its overall energy savings by a factor of 10. To manage ICT effectively, cities need a common framework for data and performance, and a set of solutions for urban sustainability.

- *Managing the Eco-Footprint of Government ICT Operations:* In keeping with the lead-by-example principle, creating a program for city operations is the first step cities must take toward reducing their ICT eco-footprint and realizing the benefits of ICT-enabled innovation.

- *Data Collection:* A Connected and Sustainable ICT initiative must start with a baseline measurement to determine which ICT systems each city owns and uses in its operations and its

eco-footprint. For any green ICT project, a city must decide what will be included when measuring its ICT eco-footprint.

- *Environmentally Responsible ICT Management:* Establishing a standard and expectation that environmental effects will be a consideration in every decision about ICT system design, procurement, and operations is the first, and most critical, step in developing the tools and processes necessary to manage ICT's eco-footprint.

- *ICT for City Operations:* Developing knowledge and awareness of the role of ICT in urban life for all leaders and managers in local government must be an explicit goal of a Connected and Sustainable ICT initiative. Technical literacy, as well as reliable data, is necessary for making intelligent decisions about transportation systems, energy generation and distribution, traffic management, healthcare policy, land use planning, building design, school system management, and a host of other basic city services. It is also important for cities to develop a cadre of technology managers who have specific "industry knowledge" about the needs and operating practices of specific government functions.

Making the connection between ICT and a truly sustainable future can help cities justify and build support for other projects such as redevelopment plans, educational programs, and municipal broadband or wireless networks. Successful development of ICT infrastructures, both physical and organizational, can in turn advance other important sustainability goals. The right ICT infrastructure and a coordinated policy for change across many city government groups can promote social inclusion and a healthier family life, while reducing the environmental effects of automobile travel and office buildings.

XI. CONNECTED AND SUSTAINABLE SOCIO-ECONOMICS

The World is facing an unprecedented convergence of crises: A climate change crisis relates to our current ways of drawing on the planet's limited natural resources. World population continues to urbanize beyond limits ever imagined, causing challenges related to urban governance, mobility, ineffective resources allocation and management. The world also collectively suffers from an unprecedented combination of a financial and economic crisis. To make the convergence of the world's challenges even more dramatic, the most productive of industrialized societies are increasingly silver-lined as population's age. In total, the convergence of crises has cumulated into nothing less than a 'perfect storm,' unprecedented in modern human history in its scale and complexity.

The "perfect storm" manifests itself visibly into the city. This is where issues related to the several crises are being felt: unemployment, lack of social integration, lack of resources for infrastructure renewal, traffic, energy shortages, exposure to climate change consequences, are abound. Local communities are the places where solutions will need to provide an impact, where investments, innovation and job creation will need to happen. Yet this recognition goes hand in hand with the understanding that local communities can and will only succeed by ensuring effective collaboration between local, national and international government and authorities on the one hand, while mobilizing the four 'P's' of Public/Private Partnerships, as well as People living in urban environments.

Urban EcoMap

The Urban EcoMap (Connected Urban Development, 2009) concept aims to provide an application for urban communities to access and engage with relevant data regarding the primary greenhouse gas (GHG) contributors—transportation, waste, and energy. Building awareness, fostering a sense of community connection and responsibility, and providing actions for citizens to take will enable the reduction of GHG in cities. In addition, it will support decision-making for policymakers and business organizations, as well as for urban design, development and operations, and the research of urban, earth, and social scientists.

The Urban EcoMap provides dynamic information to inhabitants of cities on both the community's progress toward meeting GHG-reduction goals and on the most useful, locally available tools and resources for reducing their carbon footprint.

XII.POWERED BY AN URBAN SERVICES PLATFORM

The CUD proof of concept projects, described in the concept outlines above, fit into the wider urban blueprint whereby CUD ultimately envisions a global urban services platform approach for—and among— cities. Services are envisaged to include, but are not limited to, citizen engagement, collaboration, community-building, professional geo-referential data, real-time environmental and energy metering and monitoring, simulations for real estate development, transportation planning, location marketing, and city scenario planning.

To tackle global climate change, we need a global view, which requires a global, open-standards approach. An urban services platform approach is based on an ecosystem that encompasses an eco-centric set of technologies and standards that allow for interoperability of applications and devices. Much like the internet, the platform comprises a multi-layer stack of standards that defines how applications and devices consume and share information. Applications publish (contribute) data to the ecosystem, and other applications can then discover and consume it. This will allow for a single, global system and, more important, a global "pulse" of the eco-health of our planet.

XIII. CONCLUSION: CONNECTING WITHIN AND AMONG CITIES

The CUD vision is to create a global community of cities committed to sustainability. This focus is reflected in the CUD theme, "Connecting Cities: Achieving Sustainability through Innovation," which refers both to the need to connect *within* cities (which, by inference, includes technology) and to the importance of connecting *among* cities. It is the start of a dialogue, and a resulting 'pattern language' regarding how cities can develop coherent, long-term policies and plans to manage the environmental impacts of ICT, and to utilize ICT strategically for creating sustainable 21st century cities.

XIV. BIBLIOGRAPHY

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